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(71)Applicant : **SUMITOMO ELECTRIC IND LTD**

(72)Inventor : **UCHINO KATSUYA**
MORIGUCHI HIDEKI
NAKADO MASUO
KOBAYASHI AKINORI

(54) COVERED CERAMICS CUTTING TOOL AND ITS MANUFACTURE

(57)Abstract:

PURPOSE: To provide a cover ceramics cutting tool being excellent in both abrasion resistance an din chipping resistance, with hard ceramics as a parent material, and its manufacture.

CONSTITUTION: This cover ceramics cutting tool is equipped with a cover layer consisting of an inner cover layer 0.5-15μm thick, which is a single layer or plural layers of compounds of carbides, nitrides, etc., of Ti, Zr, or Hf provided on the surface side of the parent material of hard ceramics by chemical deposition method or Al2O3 and has tensile residual stress or does not have residual stress, and an outer cover layer 0.3-5μm thick, which is a single layer or plural layers of compounds of Ti, Zr, or Hf provided on the inner cover layer by physical deposition method, Al2O3, TiAlN, or the like and has compression residual stress.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the covering ceramic cutting tool equipped with the enveloping layer of the hard ceramics on the base material of the hard ceramics or the fiber strengthening hard ceramics, and its manufacture approach.
[0002]
[Description of the Prior Art] Although the cutting tool which consists of hard ceramics or fiber strengthening hard ceramics is used for cutting, such as a casting, in order to raise a cutting efficiency, it is in the inclination to pull up cutting speed conventionally, in recent years. For this reason, the edge-of-a-blade temperature of the cutting tool under cutting becomes 800 degrees C or more, the deformation and flank wear by the heat of the edge of a blade are promoted, and the life of a cutting tool is falling remarkably.
[0003] Forming in the front face of the ceramic base material of a cutting tool the enveloping layer which consists of the monolayer or double layer of the hard ceramics with chemical vapor deposition, such as a CVD method, is proposed in order to improve the abrasion resistance of a cutting tool under such a situation, for example, so that it may be indicated by JP,56-51049,B etc. As hard ceramics which constitutes an enveloping layer, the carbide of 4A group metal of the periodic tables, such as TiC, TiN, and TiCN, a nitride, carbon nitride, or aluminum2O3 grade is common.
[0004] Since the enveloping layer generally formed with chemical vapor deposition is accompanied by diffusion between ceramic base materials, adhesion reinforcement with a base material is very strong, therefore the covering ceramic cutting tool which has this enveloping layer excels other things in abrasion resistance very much. However, on the other hand, edge-of-a-blade reinforcement fell as compared with the ceramic cutting tool which does not have an enveloping layer, and this kind of covering ceramic cutting tool had a fault inferior to defect resistance. Although the reason generates the deficit at the time of cutting by spreading the front face of an enveloping layer to the ceramics whose crack generated as an origin is a base material, since the enveloping layer of the hard ceramics which does not contain the binder which covered the front face is lacking in toughness, it was easy to generate a crack and the enveloping layer and the base material have stuck it firmly, it is easy to spread the crack generated in the enveloping layer to a base material.
[0005] Moreover, since covering temperature is usually about 1000 degrees C and an elevated temperature in the case of chemical vapor deposition, if it cools to an after [covering] room temperature (about 20 degrees C), according to the difference of the coefficient of thermal expansion of a ceramic base material and an enveloping layer, **** residual stress will work to an enveloping layer, and this **** residual stress will promote propagation of a crack. Although abrasion resistance improves so that, as for being the range of about about ten micrometers, the thickness of the enveloping layer of the covering cutting tool currently used for a current general one thickens thickness of an enveloping layer from divisor mum, the enveloping layer thicker again from the above-mentioned reason to coincidence is because **** residual stress becomes large and defect resistance falls.

[0006] On the other hand, raising the abrasion resistance of a cutting tool is proposed by JP,1-252305,A by covering inner layers, such as TiC, with chemical vapor deposition on the base material which consists of cemented carbide, and covering outer layers, such as TiCN, with physical vapor deposition, such as the ion plating method, on this inner layer. However, the cemented carbide of the ceramic cutting tool used for ultra high-speed processing to the covering cutting tool of this proposal being the cemented carbide the base material excelled [cemented carbide] in toughness, and being what aims at improvement in a stable life of the tool in the rough cutting application of an inside high speed is a brittle material with which the conditions of cutting completely differ.
[0007] Therefore, if the defect resistance of the hard ceramic enveloping layer formed with chemical vapor deposition on the ceramic base material can be raised The covering ceramic cutting tool equipped with the abrasion resistance which was excellent in this enveloping layer original, and the cutting property which was further superior to before conjointly is obtained. Also in cutting to which a load is carried out and high speed cutting of intermittent loads, such as the processing field whose deficit of the edge of a blade there were and was not practical by the conventional of-the-same-kind ceramic tool, for example, milling, and a cutting process by turning of material with a slot, or cutting of high delivery [very many] It becomes possible to be stabilized, to be able to use it or to carry out improvement in an improvement of the tool life.
[0008]
[Problem(s) to be Solved by the Invention] It aims at offering the covering ceramic cutting tool excellent in wear-resistant and defect resistant both, and offering the manufacture approach by improving the defect resistant fall which was not avoided conventionally by this invention's forming the enveloping layer of the hard ceramics in the base material of the hard ceramics or the fiber strengthening hard ceramics in view of this conventional situation, and giving the good abrasion resistance by the enveloping layer to a ceramic base material, and preparing an enveloping layer.
[0009]
[Means for Solving the Problem] In the covering ceramic cutting tool which prepared the hard enveloping layer on the front face of the base material which consists of hard ceramics of this invention, or fiber strengthening hard ceramics in order to attain the above-mentioned purpose Said hard enveloping layer in the carbide of Ti, Zr, and Hf which were prepared in the base material front-face side, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride, a HOU nitride, HOU carbon nitride and the monolayer chosen from at least one sort of aluminum 2O3, or a double layer The inside enveloping layer which has the **** residual stress whose thickness is 0.5-15 micrometers, or does not have residual stress, In the monolayer or double layer chosen from at least one sort of the carbide of Ti, Zr, and Hf which were prepared on the inside enveloping layer, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride and aluminum 2O3, titanium nitride aluminum, and acid titanium nitride aluminum Thickness is characterized by consisting of an outside enveloping layer which has compressive residual stress which is 0.3-5 micrometers.
[0010] Moreover, it sets to the manufacture approach of the covering ceramic cutting tool of this invention. On the front face of the base material which consists of hard ceramics or fiber strengthening hard ceramics with chemical vapor deposition In the carbide of Ti, Zr, and Hf, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride, a HOU nitride, HOU carbon nitride and the monolayer chosen from at least one sort of aluminum 2O3, or a double layer After thickness forms the inside enveloping layer which is 0.5-15 micrometers and cools the whole to a room temperature, On an inside enveloping layer, with physical vapor deposition, the carbide of Ti, Zr, and Hf, Thickness is characterized by forming the outside enveloping layer which is 0.3-5 micrometers in the monolayer or double layer chosen from at least one sort of a nitride, carbon nitride, a carbonation object, a carbonic acid nitride and aluminum 2O3, titanium nitride aluminum, and acid titanium nitride aluminum.
[0011] In addition, although the hard ceramics or fiber strengthening hard ceramics which is well-known in the field concerned, or is usually used for it from the former is sufficient as the base material in the covering ceramic cutting tool of this invention, the hard ceramics which makes a subject titanium compounds, such as silicon nitride, an alumina or titanium carbide, and titanium nitride, especially, or

its fiber strengthening hard ceramics which made these distribute strengthening fiber, such as silicon carbide, is desirable.
[0012]
[Function] Since the disruptive strength of an enveloping layer is inferior with 3/2 about 4 MN/m with aluminum 2O3 to the disruptive strength of the ceramics which is usually a base material being about 3/2 7 - 8 MN/m with for example, Si3N4 system or the fiber strengthening aluminum2O3 system ceramics when an enveloping layer is formed in the hard ceramics or fiber strengthening hard ceramics which is a base material with chemical vapor deposition, although an enveloping layer is a thin film, some fall on the strength is not escaped.
[0013] Moreover, to the coefficient of thermal expansion of the ceramics which is a base material being about 3.0x10-6K-1 for example, with the Si3N4 system ceramics, if TiC cools to a room temperature after enveloping layer formation from the covering temperature of about 1000 degrees C at the time of forming an enveloping layer with chemical vapor deposition with abbreviation 7.9x10-6K-1 since abbreviation 7.6x10-6K-1 and aluminum 2O3 are large, tensile stress will generate the coefficient of thermal expansion of an enveloping layer in an enveloping layer. Usually, since this stress exceeds the disruptive strength of an enveloping layer, a crack with an average spacing of 100-400 micrometers occurs in an enveloping layer, and a part of stress is released. However, in addition, distortion of 0.5 - 1.0GPa extent usually remains to an enveloping layer, and this promotes propagation of the crack at the time of cutting.
[0014] So, in this invention, it uses that the compressive stress of 1.5 - 2.0GPa extent generally remains for the enveloping layer of the hard ceramics formed with physical vapor deposition, such as the ion plating method. By preparing the outside enveloping layer which has compressive residual stress further formed with physical vapor deposition on the inside enveloping layer which has the **** residual stress formed on the base material with chemical vapor deposition like the above, or does not have residual stress The **** residual stress of an inside enveloping layer is negated, and it was made for moderate compressive stress to remain by the whole enveloping layer.
[0015] Are from the monolayer or double layer of TiC or aluminum2O3 grade on the base material front-face side of the ceramics, and the inside enveloping layer whose thickness is 0.5-15 micrometers is specifically formed with chemical vapor deposition. If it consists of a monolayer or double layers, such as TiN and TiCN, with physical vapor deposition and thickness forms an outside enveloping layer 0.3 micrometers or more on the inside enveloping layer after cooling the whole to a room temperature and making an inside enveloping layer generate a crack Each residual stress of an inside enveloping layer and an outside enveloping layer negated each other, it could check that compressive stress remains to the whole enveloping layer as a result according to the X diffraction, and the range of 0.2-2.0GPa was found by that this compressive stress that remains is desirable.
[0016] Thus, it became possible to raise the defect resistance of an enveloping layer by adjusting the residual stress of an inside enveloping layer and an outside enveloping layer, and the covering ceramic cutting tool which raised sharply the defect resistance of a cutting edge and chipping-proof nature in cutting to coincidence was able to be obtained, holding good adhesion with a ceramic base material, and the outstanding abrasion resistance as a result. However, if the thickness of an outside enveloping layer exceeds 5 micrometers, since defect resistant improvement will decrease from the total thickness becoming thick too much, the thickness of an outside enveloping layer has the desirable range of 0.3-5.0 micrometers.
[0017]
[Example] After having prepared the base material of the cutting-tool configuration of a part number SNGN432 which consists of hard ceramics of the presentation shown in the following table 1, forming in the base material front face the inside enveloping layer of the monolayer shown in Table 1 on condition that usual with a well-known CVD method, or a double layer and cooling the whole to a room temperature, the **** residual stress of an inside enveloping layer was measured according to the X diffraction. Next, the outside enveloping layer of the monolayer shown in Table 1 on condition that usual with well-known physical vapor deposition or a double layer was formed on the inside enveloping

layer, and the compressive residual stress of the whole enveloping layer was measured similarly.
[0018]
[Table 1]
Mother Material Group ** An inside enveloping layer and thickness An outside enveloping layer and a thickness sample (wt%) Base material -> (micrometer) -> outside (micrometer) 1 Si3N 4-5Y2O3 TiCN/aluminum2O3/TiN TiN/TiCN/TiN - 2aluminum 2O3 0.3 1.0 0.3 0.5 1.0 0.5 2 TiC-30aluminum 2O3 TiCO/aluminum 2O3 TiAlN 0.5 2.0 5.0 3aluminum2O3-30TiC 2O3/TiC TiC/TiN of aluminum 0.3 0.2 0.3 0.3 4 aluminum2O3-8ZrO2 aluminum2O3/HfC TiC/TiCN/TiN -28SiC whisker 1.0 2.0 0.5 1.0 0.3 2O3/TiCNO/TiCN of 5aluminum2O3aluminum TiN 0.2 0.5 0.5 0.3 6 aluminum2O3-5ZrO2 ZrC/TiC TiCN/TiC/TiN 2.0 1.0 0.3 0.3 0.3 7aluminum2O3-5ZrO2 ZrCO/ZrCN/ZrN ZrN/ZrCN/ZrC 3.0 10.02.0 1.0 1.0 1.0 8 Si3N 4-5Y2O3 HfCN/HfBCN/HfBN/aluminum2O3 HfCO/HfCNO/HfCN/HfN - 2aluminum 2O3 0.1 0.2 0.1 0.1 0.1 0.1 0.2 0.1 9* aluminum2O3-5ZrO2 ZrCNO/ZrCN/ZrN TiAlON 3.0 11.0 2.0 5.5 10* 2O3/HfCNO/HfN of aluminum2O3-30TiC aluminum TiAlNO 0.1 0.1 0.1 The samples 9 and 10 which attached 0.2(notes) * are the examples of a comparison (it is below the same).
[0019] Moreover, the **** residual stress of the inside enveloping layer measured about each sample of the above-mentioned table 1 and the compressive residual stress of the whole enveloping layer were enumerated to Table 2.
[Table 2]

試料	内側被覆層の引張残留応力	被覆層全体の圧縮残留応力
1	1.0GPa	0.2GPa
2	0.5GPa	0.9GPa
3	0.3GPa	0.2GPa
4	0.5GPa	0.2GPa
5	0	0.4GPa
6	0.3GPa	0.9GPa
7	1.0GPa	0.2GPa
8	0.3GPa	0.2GPa
9*	1.0GPa	0.4GPa
10*	0	0.1GPa

[0020] About each obtained covering ceramic cutting tool, the cutting conditions of the ultra high-speed or heavy load shown below estimated cutting-ability ability, respectively, and the result was shown in Table 3.
********** ** Material: FC25 cutting speed: 800 m/min
** **: 0.3 mm/rev
OFF ** See. : 1.0mm OFF ** Oil: Dry type life judging: Time amount (min) which amounts to VB=0.2mm
********** ** Material: Material with FC25 slot (they are four slots on the longitudinal direction to periphery good spacing)
Cutting speed: 500 m/min
** **: 0.8 mm/rev
OFF ** See. : 1.0mm OFF ** Oil: Dry type life judging: Time amount (min) to chipping generating
[0021] In Table 3, as the samples 1-8 of the example of this invention, and an example of a comparison, in addition, the thickness of an enveloping layer besides the samples 9 and 10 (an enveloping layer is displayed as CVD+PVD) with this invention out of range The example which does not have an enveloping layer only at the ceramic base material of each samples 1-10 of Table 1, the example of the CVD enveloping layer which similarly prepared only the inside enveloping layer of Table 1 in each ceramic base material of Table 1, And similarly the result of having evaluated cutting-ability ability like

the above was doubled and shown in each ceramic base material of Table 1 about the example of the PVD enveloping layer which prepared only the outside enveloping layer of Table 1.
[0022]
[Table 3]
CVD+PVD With no enveloping layer CVD enveloping layer PVD enveloping layer sample Antifriction Deficit-proof Antifriction Deficit-proof Antifriction Deficit-proof Antifriction Deficit-proof 1 8 22 3 20 6 10 3.5 17 2 14 10 9 6 12 3 8 10 3 13 9 10 6 11 4 10 8 4 14 15 6 11 11 4 8 12 5 17 312 2 15 112 2 6 1310 8 7 11 3 9 8 7 198 87 16 4 10 98 825 3 20 6 12 3.5 18 9* 214 8 7 19 0.5 156 10*10.5 6 10 610 4 10 the numeric value of the evaluation in 8 (notes) abrasion resistance and defect resistance is shown in the life judging of said cutting conditions -- as -- a part (min) -- it is .
[0023] It turns out that it is inferior to defect resistance although the covering ceramic cutting tool which has a CVD enveloping layer from the result of Table 3 compared with the usual ceramic cutting tool without an enveloping layer is excellent in abrasion resistance, and wear-resistant and defect resistant both of the covering ceramic cutting tool of the example of this invention are improving to coincidence to whether the covering ceramic cutting tool which has a PVD enveloping layer is equivalent also to abrasion resistance and defect resistance, and being inferior.
[0024]
[Effect of the Invention] The inside enveloping layer which has moderately the **** residual stress formed by chemical vapor deposition as an enveloping layer to a ceramic base material according to this invention, Since the laminating of the outside enveloping layer which has compressive residual stress formed by physical vapor deposition on the inside enveloping layer has been carried out By the residual of the suitable compressive stress in the outstanding whole adhesion reinforcement and the outstanding whole enveloping layer to the ceramic base material of an inside enveloping layer, while it has the outstanding abrasion resistance, the covering ceramic cutting tool which raised defect resistance sharply can be offered.
[0025] Therefore, according to the covering ceramic cutting tool of this invention, also in cutting to which a load is carried out and high speed cutting of intermittent loads, such as the cutting conditions which were difficult to apply, for example, milling, and a cutting process by turning of material with a slot, or cutting of high delivery, a tool life becomes long, and can stabilize and use it with the conventional ceramic cutting tool.

[Translation done.]

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CLAIMS

[Claim(s)]
[Claim 1] In the covering ceramic cutting tool which prepared the hard enveloping layer on the front face of the base material which consists of hard ceramics or fiber strengthening hard ceramics Said hard enveloping layer in the carbide of Ti, Zr, and Hf which were prepared in the base material front-face side, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride, a HOU nitride, HOU carbon nitride and the monolayer chosen from at least one sort of aluminum 2O3, or a double layer The inside enveloping layer which has the **** residual stress whose thickness is 0.5-15 micrometers, or does not have residual stress, In the monolayer or double layer chosen from at least one sort of the carbide of Ti, Zr, and Hf which were prepared on the inside enveloping layer, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride and aluminum 2O3, titanium nitride aluminum, and acid titanium nitride aluminum The covering ceramic cutting tool characterized by consisting of an outside enveloping layer which has compressive residual stress whose thickness is 0.3-5 micrometers.
[Claim 2] The covering ceramic cutting tool according to claim 1 characterized by the compressive stress of 0.2-2.0GPa remaining by the whole enveloping layer which consists of an inside enveloping layer and an outside enveloping layer.
[Claim 3] On the base material front face which consists of hard ceramics or fiber strengthening hard ceramics with chemical vapor deposition In the carbide of Ti, Zr, and Hf, a nitride, carbon nitride, a carbonation object, a carbonic acid nitride, a HOU nitride, HOU carbon nitride and the monolayer chosen from at least one sort of aluminum 2O3, or a double layer After thickness forms the inside enveloping layer which is 0.5-15 micrometers and cools the whole to a room temperature, On an inside enveloping layer, with physical vapor deposition, the carbide of Ti, Zr, and Hf, In the monolayer or double layer chosen from at least one sort of a nitride, carbon nitride, a carbonation object, a carbonic acid nitride and aluminum 2O3, titanium nitride aluminum, and acid titanium nitride aluminum The manufacture approach of the covering ceramic cutting tool characterized by forming the outside enveloping layer whose thickness is 0.3-5 micrometers.

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(71)出願人　000002130
住友電気工業株式会社
大阪府大阪市中央区北浜四丁目５番33号

(72)発明者　内野　克哉
兵庫県伊丹市昆陽北一丁目１番１号　住友電気工業株式会社伊丹製作所内

(72)発明者　森口　秀樹
兵庫県伊丹市昆陽北一丁目１番１号　住友電気工業株式会社伊丹製作所内

(72)発明者　中堂　益男
兵庫県伊丹市昆陽北一丁目１番１号　住友電気工業株式会社伊丹製作所内

(74)代理人　弁理士　中村　勝成　（外１名）

最終頁に続く

(54)【発明の名称】　被覆セラミックス切削工具及びその製造方法

(57)【要約】

【目的】　硬質セラミックスを母材とし、耐摩耗性と耐欠損性の両方に優れた被覆セラミックス切削工具及びその製造方法を提供する。

【構成】　硬質セラミックスの母材の表面側に化学的蒸着法により設けたＴｉ、Ｚｒ、Ｈｆの炭化物、窒化物等の化合物かAl_2O_3の単層又は複層で膜厚が０．５～１５μｍの引張残留応力を有するか又は残留応力を有しない内側被覆層と、内側被覆層上に物理的蒸着法により設けたＴｉ、Ｚｒ、Ｈｆの化合物かAl_2O_3、ＴｉＡｌＮ等の単層又は複層で膜厚が０．３～５μｍの圧縮残留応力を有する外側被覆層とからなる被覆層を備えた被覆セラミックス切削工具。

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【特許請求の範囲】

【請求項1】　硬質セラミックス又は繊維強化硬質セラミックスからなる母材の表面上に硬質被覆層を設けた被覆セラミックス切削工具において、前記硬質被覆層が、母材表面側に設けたTi、Zr、Hfの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、ホウ窒化物、ホウ炭窒化物、及びAl_2O_3の少なくとも1種から選ばれた単層又は複層で、膜厚が0.5～15μmの引張残留応力を有するか又は残留応力を有しない内側被覆層と、内側被覆層の上に設けたTi、Zr、Hfの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、及びAl_2O_3、窒化チタンアルミニウム、酸窒化チタンアルミニウムの少なくとも1種から選ばれた単層又は複層で、膜厚が0.3～5μmの圧縮残留応力を有する外側被覆層とからなることを特徴とする被覆セラミックス切削工具。

【請求項2】　内側被覆層と外側被覆層からなる被覆層全体で0.2～2.0GPaの圧縮応力が残留していることを特徴とする、請求項1記載の被覆セラミックス切削工具。

【請求項3】　化学的蒸着法により硬質セラミックス又は繊維強化硬質セラミックスからなる母材表面上に、Ti、Zr、Hfの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、ホウ窒化物、ホウ炭窒化物、及びAl_2O_3の少なくとも1種から選ばれた単層又は複層で、膜厚が0.5～15μmの内側被覆層を形成し、全体を室温まで冷却した後、物理的蒸着法により内側被覆層の上に、Ti、Zr、Hfの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、及びAl_2O_3、窒化チタンアルミニウム、酸窒化チタンアルミニウムの少なくとも1種から選ばれた単層又は複層で、膜厚が0.3～5μmの外側被覆層を形成することを特徴とする被覆セラミックス切削工具の製造方法。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、硬質セラミックス又は繊維強化硬質セラミックスの母材上に、硬質セラミックスの被覆層を備えた被覆セラミックス切削工具、及びその製造方法に関する。

【0002】

【従来の技術】硬質セラミックス又は繊維強化硬質セラミックスからなる切削工具は、鋳物等の切削加工に使用されているが、近年では切削効率を高めるために切削速度を従来よりも引き上げる傾向にある。このため、切削中における切削工具の刃先温度は800℃以上になり、刃先の熱による変形や逃げ面摩耗が促進され、切削工具の寿命が著しく低下している。

【0003】この様な状況下で切削工具の耐摩耗性を改善するため、例えば特公昭56－51049号公報等に記載されるごとく、切削工具のセラミックス母材の表面

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に、CVD法等の化学的蒸着法により硬質セラミックスの単層又は複層からなる被覆層を形成することが提案されている。被覆層を構成する硬質セラミックスとしてはTiC、TiN、TiCN等の周期律表の4A族金属の炭化物、窒化物、炭窒化物、或はAl_2O_3等が一般的である。

【0004】一般的に化学的蒸着法により形成した被覆層は、セラミックス母材との間に拡散を伴うため母材との密着強度が非常に強く、従ってかかる被覆層を有する被覆セラミックス切削工具は他のものより耐摩耗性が非常に優れている。しかしその一方で、この種の被覆セラミックス切削工具は、被覆層を有しないセラミックス切削工具に比較して刃先強度が低下し、耐欠損性に劣る欠点があった。その理由は、切削時における欠損は被覆層の表面を起点として発生した亀裂が母材であるセラミックスへ伝播することにより発生するが、表面を被覆したバインダーを含まない硬質セラミックスの被覆層は靭性に乏しいことから亀裂が発生しやすく、又被覆層と母材が強固に密着しているので被覆層に発生した亀裂が母材に伝播しやすいためである。

【0005】又、化学的蒸着法の場合には被覆温度が通常約1000℃と高温であるため、被覆後室温（約20℃）まで冷却するとセラミックス母材と被覆層との熱膨張係数の差によって被覆層に引張残留応力が働くことになり、この引張残留応力が亀裂の伝播を助長する。現在一般に使用されている被覆切削工具の被覆層の膜厚が約数μmから約10数μmの範囲であるのは、被覆層の膜厚を厚くするほど耐摩耗性が向上するものの、同時にまた上記の理由から厚い被覆層ほど引張残留応力が大きくなって耐欠損性が低下するからである。

【0006】一方、特開平1－252305号には、超硬合金からなる母材の上に化学的蒸着法によりTiC等の内層を被覆し、この内層上にイオンプレーティング法等の物理的蒸着法によりTiCN等の外層を被覆することによって、切削工具の耐摩耗性を向上させることが提案されている。しかしこの提案の被覆切削工具は、母材が靭性に優れた超硬合金であり、中高速の粗切削用途での工具の安定寿命向上を図るものであるのに対して、超高速加工に使用するセラミックス切削工具は超硬合金とは切削加工の条件が全く異なる脆性材料である。

【0007】従って、セラミックス母材上に化学的蒸着法により形成した硬質セラミックス被覆層の耐欠損性を向上させることが出来れば、この被覆層本来の優れた耐摩耗性と相俟って、従来よりも一層優れた切削特性を備えた被覆セラミックス切削工具が得られ、従来の同種セラミックス工具では刃先の欠損が極めて多く実用的でなかった加工領域、例えばフライス加工や溝付き材の旋削加工等の断続的荷重の負荷される切削加工や高速切削又は高送りの切削加工においても、安定して使用でき又は工具寿命を改善向上させることが可能となる。

【0008】

【発明が解決しようとする課題】本発明はかかる従来の事情に鑑み、硬質セラミックス又は繊維強化硬質セラミックスの母材に硬質セラミックスの被覆層を形成し、セラミックス母材に被覆層による良好な耐摩耗性を付与し、且つ被覆層を設けることにより従来避けられなかった耐欠損性の低下を改善することによって、耐摩耗性と耐欠損性の両方に優れた被覆セラミックス切削工具を提供すること、及びその製造方法を提供することを目的とする。

【0009】

【課題を解決するための手段】上記目的を達成するため、本発明の硬質セラミックス又は繊維強化硬質セラミックスからなる母材の表面上に硬質被覆層を設けた被覆セラミックス切削工具においては、前記硬質被覆層が、母材表面側に設けたＴｉ、Ｚｒ、Ｈｆの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、ホウ窒化物、ホウ炭窒化物、及びAl_2O_3の少なくとも１種から選ばれた単層又は複層で、膜厚が０.５～１５μｍの引張残留応力を有するか又は残留応力を有しない内側被覆層と、内側被覆層の上に設けたＴｉ、Ｚｒ、Ｈｆの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、及びAl_2O_3、窒化チタンアルミニウム、酸窒化チタンアルミニウムの少なくとも１種から選ばれた単層又は複層で、膜厚が０.３～５μｍの圧縮残留応力を有する外側被覆層とからなることを特徴とする。

【0010】又、本発明の被覆セラミックス切削工具の製造方法においては、化学的蒸着法により硬質セラミックス又は繊維強化硬質セラミックスからなる母材の表面上に、Ｔｉ、Ｚｒ、Ｈｆの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、ホウ窒化物、ホウ炭窒化物、及びAl_2O_3の少なくとも１種から選ばれた単層又は複層で、膜厚が０.５～１５μｍの内側被覆層を形成し、全体を室温まで冷却した後、物理的蒸着法により内側被覆層の上に、Ｔｉ、Ｚｒ、Ｈｆの炭化物、窒化物、炭窒化物、炭酸化物、炭酸窒化物、及びAl_2O_3、窒化チタンアルミニウム、酸窒化チタンアルミニウムの少なくとも１種から選ばれた単層又は複層で、膜厚が０.３～５μｍの外側被覆層を形成することを特徴とする。

【0011】尚、本発明の被覆セラミックス切削工具における母材は、従来から当該分野に公知であり又は通常使用されている硬質セラミックス又は繊維強化硬質セラミックスで良いが、なかでも窒化ケイ素、アルミナ、又は炭化チタンや窒化チタン等のチタン化合物を主体とする硬質セラミックス、若しくはこれらに炭化ケイ素等の強化繊維を分散させた繊維強化硬質セラミックスが好ましい。

【0012】

【作用】母材である硬質セラミックス又は繊維強化硬質セラミックスに化学的蒸着法により被覆層を形成した場合、通常は母材であるセラミックスの破壊強度が例えばSi_3N_4系や繊維強化Al_2O_3系セラミックスで７～８ＭＮ／$m^{3/2}$程度であるのに対して、被覆層の破壊強度は例えばAl_2O_3で約４ＭＮ／$m^{3/2}$と劣っているので、被覆層が薄膜であるとはいえ若干の強度低下は免れない。

【0013】又、母材であるセラミックスの熱膨張係数は例えばSi_3N_4系セラミックスで$3.0\times10^{-6}K^{-1}$程度であるのに対して、被覆層の熱膨張係数は例えばＴｉＣが約$7.6\times10^{-6}K^{-1}$及びAl_2O_3が約$7.9\times10^{-6}K^{-1}$と大きいので、化学的蒸着法で被覆層を形成する際の被覆温度約１０００℃から被覆層形成後に室温まで冷却すると被覆層に引張応力が発生する。通常この応力は被覆層の破壊強度を越えるので、被覆層に平均間隔１００～４００μｍの亀裂が発生し、応力の一部が解放される。しかし、通常は被覆層になお０.５～１.０ＧＰａ程度の歪みが残留し、これが切削時の亀裂の伝播を助長するのである。

【0014】そこで本発明では、イオンプレーティング法等の物理的蒸着法により形成した硬質セラミックスの被覆層には一般に１.５～２.０ＧＰａ程度の圧縮応力が残留することを利用し、上記のごとく化学的蒸着法により母材上に形成した引張残留応力を有するか又は残留応力を有しない内側被覆層の上に、更に物理的蒸着法により形成した圧縮残留応力を有する外側被覆層を設けることによって、内側被覆層の引張残留応力を打ち消し被覆層全体で適度な圧縮応力が残るようにした。

【0015】具体的には、セラミックスの母材表面側にＴｉＣやAl_2O_3等の単層又は複層からなり膜厚が０.５～１５μｍの内側被覆層を化学的蒸着法により形成し、全体を室温まで冷却して内側被覆層に亀裂を発生させた後、その内側被覆層の上に物理的蒸着法によりＴｉＮやＴｉＣＮ等の単層又は複層からなり膜厚が０.３μｍ以上の外側被覆層を形成すれば、内側被覆層と外側被覆層の各々の残留応力が打ち消し合い、結果的に被覆層全体に圧縮応力が残留することがＸ線回折により確認でき、この残留する圧縮応力は０.２～２.０ＧＰａの範囲が好ましいことも分かった。

【0016】この様に内側被覆層と外側被覆層の残留応力を調整することにより、被覆層の耐欠損性を向上させることが可能となり、その結果セラミックス母材との良好な密着性と優れた耐摩耗性を保持したまま、同時に切削における切刃の耐欠損性及び耐チッピング性を大幅に向上させた被覆セラミックス切削工具を得ることが出来た。ただし、外側被覆層の膜厚が５μｍを越えると、総膜厚が厚くなり過ぎることから耐欠損性の向上が少なくなるので、外側被覆層の膜厚は０.３～５.０μｍの範囲が好ましい。

【0017】

【実施例】下記表１に示す組成の硬質セラミックスから

なる型番ＳＮＧＮ４３２の切削工具形状の母材を用意し、母材表面に公知のＣＶＤ法により通常の条件で表１に示す単層又は複層の内側被覆層を形成し、全体を室温に冷却した後、Ｘ線回折により内側被覆層の引張残留応力を測定した。次に、内側被覆層の上に公知の物理的蒸＊着法により通常の条件で表１に示す単層又は複層の外側被覆層を形成し、同様に被覆層全体の圧縮残留応力を測定した。

【００１８】

【表１】

試料	母材組成 (wt%)	内側被覆層と膜厚 母材→ (μm)	外側被覆層と膜厚 →外側 (μm)
1	Si_3N_4－5Y_2O_3－2Al_2O_3	TiCN／Al_2O_3／TiN 0.3 1.0 0.3	TiN／TiCN／TiN 0.5 1.0 0.5
2	TiC－30Al_2O_3	TiCO／Al_2O_3 0.5 2.0	TiAlN 5.0
3	Al_2O_3－30TiC	Al_2O_3／TiC 0.3 0.2	TiC／TiN 0.3 0.3
4	Al_2O_3－8ZrO_2－28SiCウイスカー	Al_2O_3／HfC 1.0 2.0	TiC／TiCN／TiN 0.5 1.0 0.3
5	Al_2O_3	Al_2O_3／TiCNO／TiCN 0.2 0.5 0.5	TiN 0.3
6	Al_2O_3－5ZrO_2	ZrC／TiC 2.0 1.0	TiCN／TiC／TiN 0.3 0.3 0.3
7	Al_2O_3－5ZrO_2	ZrCO／ZrCN／ZrN 3.0 10.0 2.0	ZrN／ZrCN／ZrC 1.0 1.0 1.0
8	Si_3N_4－5Y_2O_3－2Al_2O_3	HfCN／HfBCN／HfBN／Al_2O_3 0.1 0.2 0.1 0.1	HfCO／HfCNO／HfCN／HfN 0.1 0.1 0.2 0.1
9＊	Al_2O_3－5ZrO_2	ZrCNO／ZrCN／ZrN 3.0 11.0 2.0	TiAlON 5.5
10＊	Al_2O_3－30TiC	Al_2O_3／HfCNO／HfN 0.1 0.1 0.1	TiAlNO 0.2

（注）＊を付した試料９と１０は比較例である（以下同じ）。

【００１９】又、上記表１の各試料について測定した内側被覆層の引張残留応力と、被覆層全体の圧縮残留応力を表２に列挙した。

【表２】

試料	内側被覆層の引張残留応力	被覆層全体の圧縮残留応力
1	1.0GPa	0.2GPa
2	0.5GPa	0.9GPa
3	0.3GPa	0.2GPa
4	0.5GPa	0.2GPa
5	0	0.4GPa
6	0.3GPa	0.9GPa
7	1.0GPa	0.2GPa
8	0.3GPa	0.2GPa
9＊	1.0GPa	0.4GPa
10＊	0	0.1GPa

【００２０】得られた各被覆セラミックス切削工具について、下記に示す超高速又は高負荷の切削条件にて切削性能をそれぞれ評価し、結果を表３に示した。

耐摩耗性

被削材：　ＦＣ２５

※切削速度：　８００ｍ／ｍｉｎ．
送　り：　０．３ｍｍ／ｒｅｖ．
切込み：　１．０ｍｍ
切削油：　乾式
寿命判定：　V_B＝０．２ｍｍに達する時間（ｍｉｎ）

耐欠損性

被削材：　ＦＣ２５溝付き材（外周上等間隔に長手方向の溝４本）
切削速度：　５００ｍ／ｍｉｎ．
送　り：　０．８ｍｍ／ｒｅｖ．
切込み：　１．０ｍｍ
切削油：　乾式
寿命判定：　チッピング発生までの時間（ｍｉｎ）

【００２１】尚、表３には本発明例の試料１～８と比較例として被覆層の膜厚が本発明の範囲外である試料９及び１０（被覆層をＣＶＤ＋ＰＶＤと表示）のほかに、表１の各試料１～１０のセラミックス母材のみで被覆層のない例、同じく表１の各セラミックス母材に表１の内側被覆層のみを設けたＣＶＤ被覆層の例、及び同じく表１の各セラミックス母材に表１の外側被覆層のみを設けたＰＶＤ被覆層の例についても、上記と同様に切削性能を評価した結果を合わせて示した。

【００２２】

【表3】

	CVD+PVD		被覆層なし		CVD被覆層		PVD被覆層	
試料	耐摩耗	耐欠損	耐摩耗	耐欠損	耐摩耗	耐欠損	耐摩耗	耐欠損
1	8	22	3	20	6	10	3.5	17
2	14	10	9	6	12	3	8	10
3	13	9	10	6	11	4	10	8
4	14	15	6	11	11	4	8	12
5	17	3	12	2	15	1	12	2
6	13	10	8	7	11	3	9	8
7	19	8	8	7	16	4	10	9
8	8	25	3	20	6	12	3.5	18
9*	21	4	8	7	19	0.5	15	6
10*	10.5	6	10	6	10	4	10	8

（注）耐摩耗性及び耐欠損性における評価の数値は前記切削条件の寿命判定に示すごとく分（ｍｉｎ）である。

【００２３】表３の結果から、被覆層のない通常のセラミックス切削工具に比べて、ＣＶＤ被覆層を有する被覆セラミックス切削工具は耐摩耗性に優れるが耐欠損性に劣り、ＰＶＤ被覆層を有する被覆セラミックス切削工具は耐摩耗性及び耐欠損性とも同等か劣るのに対して、本発明例の被覆セラミックス切削工具は耐摩耗性と耐欠損性の両方が同時に向上していることが分かる。

【００２４】

【発明の効果】本発明によれば、セラミックス母材への被覆層として、化学的蒸着法により形成された引張残留応力を適度に有する内側被覆層と、内側被覆層の上に物＊理的蒸着法により形成された圧縮残留応力を有する外側被覆層とを積層してあるので、内側被覆層のセラミックス母材への優れた密着強度と被覆層全体での好適な圧縮応力の残留により、優れた耐摩耗性を有すると同時に耐欠損性を大幅に向上させた被覆セラミックス切削工具を提供することが出来る。

【００２５】従って、本発明の被覆セラミックス切削工具によれば、従来のセラミックス切削工具では適用が困難であった切削条件、例えばフライス加工や溝付き材の旋削加工等の断続的荷重の負荷される切削加工や高速切削又は高送りの切削加工においても、工具寿命が長くなり、安定して使用することが出来る。

フロントページの続き

(72)発明者　小林　晄徳
兵庫県伊丹市昆陽北一丁目１番１号　住友
電気工業株式会社伊丹製作所内